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F W Putnam

THE

National Geographic Magazine

Vol. IX OCTOBER, 1898 No. 10

LAKE CHELAN

By Henry Gannett,

Chief Geographer, U. S. Geological Survey

To most readers, especially those of the East, this title conveys little information, for it is an almost unknown lake, in an almost unknown region. It lies in the northwestern part of the state of Washington, upon the eastern slope of the Cascade range, its lower end being near Columbia river, into which it is drained; thence it stretches northwestward in a long, winding ribbon, far up toward the heart of the range. Into the head of the lake flows Stehekin river, whose sources are in Cascade pass, at the summit of Cascade range. The river has numerous branches, all of which head in high, snowy mountains, among small glaciers, and it consequently brings a considerable volume of water to the lake.

In the northern part of Washington the Cascade range consists of a broad and extremely rugged mass of granite mountains, whose highest summits are between 10,000 and 11,000 feet in altitude. High up in the heads of the gorges and at the foot of the peaks are many small glaciers, the remains of others, much larger, which in times past extended far down the present stream valleys, filling them to great depths with streams of ice. Evidences of these are present in all the valleys and gorges of this part of the Cascade range. The occupation of these gorges by glaciers is so recent that in many of them the subsequent work of the streams by which they are now occupied has produced but trifling results. Only in a few places are evidences of extensive stream erosion seen.

The bed of Lake Chelan and its principal tributary, Stehekin river, together with the branches of that river, were at one time filled by a vast glacial system, extending from the crest of the Cascades southeastward nearly to Columbia river. The glacier was nearly 100 miles long, and when it was in its prime the ice must have been several thousand feet in thickness.

MAP OF LAKE CHELAN AND VICINITY, IN THE STATE OF WASHINGTON, [illegible]

A glacier is a river of ice, and it behaves almost precisely as a river of water does. Its effects upon its channel are almost precisely similar to those of a river upon its channel, excepting in the fact that all its operations are on a vastly greater scale. The channel of a river may be measured by yards or hundreds of yards, while that of a glacier is measured in miles. The depth

of a river may be a few feet only or a few scores of feet; that of a glacier may be thousands of feet. It is this greater size, volume, and weight which makes glacial ice behave like water. In such large masses ice is plastic, accommodating itself to inequalities of its bed, flowing with some freedom, spreading out and contracting, much as water does.

A word of caution must here be interpolated. The channel of a river, in which its water flows, must not be confused with its valley, which it drains. The above comparison refers to the *channel* of a river, not to its valley.

Glaciers in mountain regions commonly head in amphitheaters or cirques—basins lying directly at the heads of cañons, under the shadow of the summit cliffs. An amphitheater is surrounded on three sides by vertical walls or steep slopes, down which the ice and snow slide in avalanches, accumulating in the bottom. The effect is precisely like that of a waterfall. The falling snow and ice dig a hollow or depression at the foot of the steep descent just as water does. Such amphitheaters are found at the heads of all glacial gorges in high mountains, and today are found to contain small alpine lakes in place of the ice which once occupied them. From its head in the amphitheater the glacier moves down the gorge scouring and cutting the bottom and sides as it travels. The ends of the mountain spurs are planed off instead of being trimmed to sharp, angular points as is done by streams in gorges cut by them. If the bottom of the cañon be uneven, if it contain abrupt elevations and depressions, the glacier flows over them as water would flow over similar obstacles in its channel, gradually cutting them away. Where the descent becomes abruptly steeper the ice, in bending to follow the surface, is commonly cracked, forming a network of crevasses, making travel over its surface very difficult and dangerous.

Where the main glacier is joined by a branch, the bed of the branch is commonly found to be at a higher level than the bed of the main glacier, because being larger and heavier the main glacier has greater cutting power; indeed, in many cases the beds of small branches are hundreds, or even thousands, of feet higher than that of the main glacier to which they are tributary. The parallelism between the glacier and the river in their channels is further illustrated by this fact. The surface of the ice in the main glacier and in the branch must have been at the same level, although the bottoms, as stated above, differ greatly

in elevation. So it is with a river at the point of junction of branches. The surface of the water must be practically at the same level in all cases, but the bottoms of the channels differ by the difference in depth of the streams at their point of junction. This fact affords us a measure of the minimum thickness of the ice at any place. It cannot have been less than the vertical distance between the bed of the main glacier and that of the tributary, and, indeed, must in all cases have been greater, owing to the thickness of the tributary.

LAKE CHELAN, AT THE NARROWS

To extend the comparison between a river and a glacier, it may be added that the central portion of the glacier flows faster than the bottom and sides, as they are retarded by friction, just as in the case of a stream. This is demonstrated by the gradually increasing curvature of the lines crossing the glacier, such as transverse lines of dirt or crevasses. In the upper portion of the glacier these may be straight, or nearly so, but lower down become more and more curved, with the convexity downward.

A glacier is constantly receiving upon its surface rock, gravel,

etc., which fall upon it from its walls. In its long journey from its source to its melting point, a journey which may occupy many years, large quantities of such material accumulate, and it naturally falls mainly upon the edges of the glacier, forming lateral moraines. Where two branches join the two lateral moraines on the inside join and form a medial moraine, and thus in a complicated glacier system the main glacier below the junction of a number of branches may bear upon its surface many

WEST SIDE OF HORSESHOE BASIN

moraines lying lengthwise with the glacier. At the melting point all these moraines are dropped in a confused heap, forming the terminal moraine. This may extend for a considerable distance up and down the valley, because the foot of the glacier moves backward and forward according to the season. In a wet, cold season the foot advances down the gorge, while in a warm, dry season it retreats toward its source.

Herein we may see another point of similarity between the

glacier and a certain type of river. In the arid regions of the West the streams which have their sources in the mountains flow down into the valleys and disappear, being absorbed by the dry soil and the thirsty atmosphere. These streams, like glaciers, bear detritus down from the mountains, and upon their disappearance in the valley they drop this detritus as the glacier does.

There are, therefore, certain characteristics by which the gorge produced by glacial erosion may be distinguished from that produced by aqueous erosion. The glacial gorge has the shape of

CASCADE PASS AND AMPHITHEATER

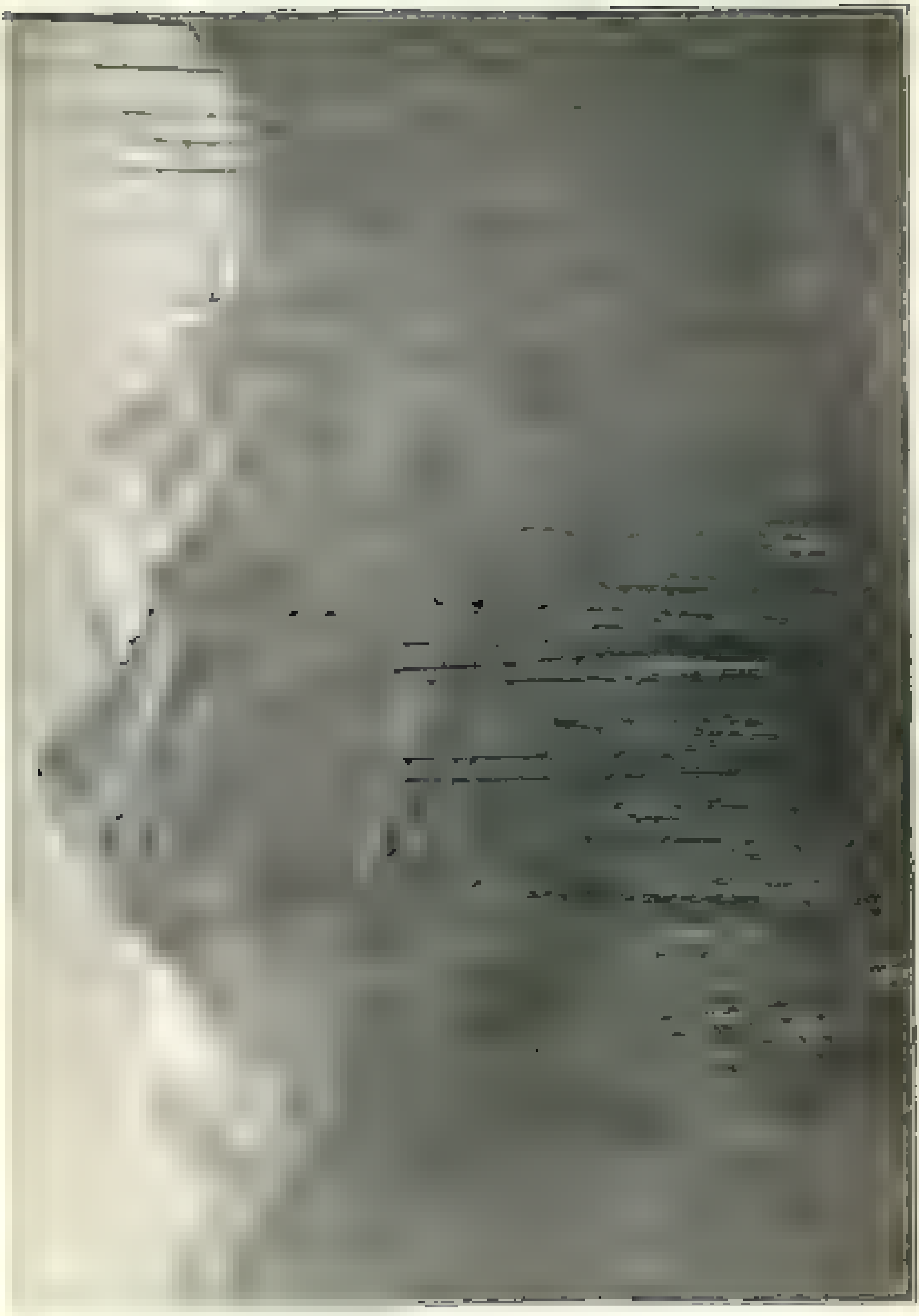
the capital letter U, while the waterworn gorge is a V-shaped notch. In a glacial gorge the spurs separating the tributaries have their ends blunted or planed off, while in a waterworn gorge they are sharp and angular. In a glacial gorge the tributaries enter the valley above its level, while in a waterworn gorge they commonly grade down to its level. A glacial gorge has an amphitheater at its head; a waterworn gorge has not. A glacial gorge is commonly lined near its lower end with lateral moraines and across its foot stretches a terminal moraine, and often this terminal moraine has formed a lake.

With the exception of lateral moraines, Lake Chelan and its tributaries present but few features peculiar to glacial [illegible], and owing to the fact that the ice has but recently abandoned the gorges, and recent erosion has made but little progress, the glacial forms are but little modified and are still the most prominent features in the landscape.

Crossing Cascade pass from the west, one descends immediately into a common amphitheater, enclosed on the west and south by a mountain wall surmounted by sharp peaks. On the north is the pass and on the east the land rises slightly, forming the lower rim of the amphitheater. The hollow of this amphitheater contains, all the year around, a great snow-field a mile or more in length, which gives rise to Stehekin river. The accompanying illustration is taken from the rim of the amphitheater looking toward the pass, which appears in the background, with the snow-field below it.

From the edge [illegible] of the lower rim of the amphitheater there is a steep descent of several hundred feet, down which the Stehekin plunges in a series of cascades. The valley, at first narrow, broadens as it becomes deeper and the U-shaped form of a glacial valley becomes more pronounced. On either side at short intervals small branches join the stream. These lead among [illegible] over which they leap in great falls. One such stream heads in [illegible] basin, on the left-hand side of Stehekin river, where its waters are derived from a small glacier. The waterfall known as [illegible] falls is one leap of the stream over the edge of the [illegible] which here is practically vertical.

The walls of the gorge along Stehekin river range from 4,000 to 5,000 feet in altitude above the bottom of the valley, and the slope ranges from near vertical at the top to 40° or 45°. Near the mouth of Company creek, some 15 miles above the head of the lake, the wall is fully 6,000 feet in height, descending in one great sweep from the summit of the mountains down to the bottom. Company creek, coming in on the right, [illegible] a large stream, flows on a level several hundred feet above the bed of Stehekin. [illegible] creek, which joins the Stehekin three or four miles farther down, coming in from the right, has a large branch that flows in a valley several hundred feet above that of the Stehekin, descending to it by a series of cascades and [illegible] in a waterworn gorge 200 or 300 feet deep, which at



has not since the retreat of the glacier. [illegible] gorge has numerous branches, and at the junction of each of these branches [illegible] of the main [illegible], although in case the branches are nearly equal in size the bench [illegible] the glacial valley [illegible]. From [illegible] it appears that the ice must have been at least 3,000 feet [illegible] gorge. [illegible] the glacier [illegible] height above its bed.

Lake Chelan [illegible] between 50 and 60 [illegible] length and [illegible] a mile or more in breadth. Except near [illegible] end, it is enclosed throughout its course between high, steep walls, rising at angles of 4[illegible]° to 4[illegible]° directly from the water's edge to an altitude of [illegible],000 or 6,000 feet above the sea. The elevation of the lake above the sea is 1,1[illegible] feet, and its cañon walls rise 4,000 or 5,000 feet above its surface. Nearly all the streams which flow into it are small, and tumble over its walls in a series of cascades. There is [illegible] stream of [illegible], Railroad creek, which [illegible] tributary to the lake, which is upon the west side, leads to the divide of the Cascade range among the high peaks where its sources are fed from living glaciers, and its valley is a glacial gorge.

Near its upper end the lake is narrow and its depth increases gradually, but about [illegible] of its length it reaches a depth of [illegible] feet, its bottom being therefore 400 feet below sea-level. [illegible] its depth [illegible] gradually to the lower end, but not so regularly as it increases. The rock walls which enclose the lake are strikingly parallel to one another. The high mountains which border it [illegible] extend down nearly to the [illegible] end, and then suddenly [illegible] to the lower country [illegible] upon the east side and [illegible] upon the west.

The country [illegible] the lake is [illegible] the [illegible] of the glacier. The lake is now drained by a stream which has cut through its terminal moraine, and after a short course of three miles and a descent of 400 feet joins the Columbia. Above the present outlet are [illegible] former outlets of the lake in the shape of gorges, cut through from the west, or rather south, side of the lake to the Columbia river. The lower of these, known as [illegible], which leaves the lake [illegible] above its present outlet, has an elevation, at its summit, of about [illegible] feet above the present level of the lake, [illegible] a sharp descent to the Columbia river at its lower end. [illegible] the lake at a [illegible] above its present outlet, [illegible]

lower, its summit being only about 400 feet above the present lake level.

Lake Chelan is not difficult of access. The traveler leaves the Great Northern railway at Wenatchee, and from that river town twice a week a little steamer ascends the swift current of the Columbia for forty miles, to the mouth of Chelan river, and a stage covers the remaining three or four miles to the outlet of the lake, where is situated the little town of Lakeside. On the days when the steamer does not run on the Columbia the journey from Wenatchee to Lakeside may be made by stage. The lake is traversed by a small steamer which, leaving Lakeside in the morning, touches at Stehekin, at the head of the lake, where there is a hotel, late in the afternoon, returning the next day. On the shores of the lower part of the lake there are numerous ranches, but within the mountain portion the only signs of habitation are a few landings, and above Stehekin there are no settlements, and travel in this region must be upon horseback with pack train.

FREDERIC W. PUTNAM.

President of the American Association for the Advancement of Science.

Fiftieth Anniversary Meeting, Boston, 1898.

The presidency of the American Association passes this year from a chemist to an anthropologist, and that of the British Association from an anthropologist to a chemist, and there are no more illustrious names in the scientific annals of the world than those to which the names of Gibbs and Putnam, Evans and Crookes are now added. The election of Professor Frederic Ward Putnam as President of the American Association was an event of more than ordinary interest and satisfaction to American men of science, Professor Putnam having not only established his claim to such recognition by forty years' scientific work of the highest character, but also won the admiration and regard of scientific men everywhere by the unusual ability, the marvelous tact, the untiring zeal, and the unfailing courtesy with which he has served the cause of science during the long period of twenty-five years as permanent Secretary of the American Association.

Frederic Ward Putnam was born in Salem, Massachusetts, April 16, 1839. His immediate ancestors were also [illegible] the first half of the seventeenth century. Young Putnam received private instruction at home, and as he [illegible] to the study of natural history his parents [illegible] him every facility for the pursuit of his favorite study. When he was but sixteen years of age he had compiled a "Catalogue of the Birds of Essex County, Massachusetts," and about the same time he was made curator of ornithology in the Essex Institute.

At this time the attention of Louis Agassiz was drawn to the young man's devotion to natural history, and [illegible] went to Cambridge, where he entered the Lawrence Scientific School intending to devote himself to [illegible]. This intention was not carried out from the fact that he was soon made assistant in the Zoölogical Museum and afterward appointed curator of the Peabody Museum. His [illegible] time for scientific pursuits, aided by the excellent [illegible]

ported to him by his friend and master Agassiz, prepared young Putnam in a most admirable manner for his life work in science, and [illegible] of his acceptance of the position in the Essex Institute he has always been indebted for a great deal of [illegible] scientific work. In 1856 he was elected [illegible] of the Boston Society of Natural History. In 1867 he became director of the museum of the Essex Institute, and three years later was made superintendent of the East India Marine Society's museum, and when the Peabody Academy of Science was established he was made director of [illegible]. In 1873 he was elected permanent secretary of the American Association for the Advancement of Science. In 1876 he was appointed a member of the Kentucky geological survey [illegible] of the caves of the [illegible]. In [illegible] he was [illegible] for [illegible] at [illegible] of Professor Jeffries Wyman [illegible] curator of the Peabody Museum. In January 1875, he was [illegible] Museum [illegible]

In 18[illegible] he was appointed [illegible] of the [illegible] in 1879. In 1887 he was elected president of the Boston Society of Natural History, retaining the office two years. In 1882 he was appointed state [illegible] by Governor Long, [illegible] he remained for seven years. In 1886 he was [illegible] the [illegible] chair of American Archaeology and Ethnology in Harvard University. Since 1880 he has been president of the Boston branch of the American Folk-lore Society, and in 1891 was president of that society. In 1891 he was at the head of the Department of Ethnology at the Chicago exposition, retaining [illegible] until the fair closed. In April, 1894 he was appointed curator of the [illegible] of the American Museum of Natural History in New York, and his time is now divided between this institution and the Peabody Museum in Cambridge.

[illegible] 1870 Professor Putnam was an ardent worker [illegible] authority in zoology, making for himself an enviable name by

[illegible] that date [illegible] in the department of Ethnology. [illegible] interest [illegible] Mexico. [illegible] caves in various parts of North America, and for many years [illegible] in the United States and Mexico and in Central and South America. He [illegible] the collections of the [illegible] American Museum of Natural History in New York, and the Field Columbian Museum in Chicago. [illegible] one of the founders of the [illegible] in 1888. He [illegible] reports and [illegible] magazine [illegible]

MESA VERDE

By F. H. NEWELL,

Chief Hydrographer, U. S. Geological Survey

The Mesa Verde [illegible] in the extreme southwestern corner of Colorado, [illegible] the Mesa Verde [illegible] it has many attractions for the geographer [illegible] formerly stretched [illegible] westerly from the country where now arise the [illegible] La Plata mountains. During the course of geologic time the same forces which uplifted the La Plata [illegible] mountains, it was deeper than [illegible] the Mesa Verde [illegible] as a great table-land roughly tilted toward the south, presenting to view from all sides sharp precipitous edges. On the north is the bold promontory known as Point Lookout, forming

toward the La Plata [illegible]; on the west is the broad Montezuma valley, drained by tributaries of McElmo creek; on the east is the valley of Mancos river, and to the south the narrow canyon through which Mancos river discharges its waters [illegible] southward into the San Juan river.

Standing on the southern edge of the Mesa Verde and looking across the deep canyons of the tributaries of the Mancos, it is seen that the same plain extends [illegible] far to the south into New Mexico; [illegible] what appears to be a level surface is found upon traversing the country to be a land deeply dissected and almost impassable except along the [illegible] edges of the [illegible].

The Mesa Verde derives its name from the fact that its top is densely covered with a growth of cedar and piñon trees, contrasting with the arid and almost desolate lowlands. In viewing the mesa from a distance and in going around it the impression is received that its surface must be a plain, but upon more closely examining the top of the mesa it is found that it is probably more like a [illegible] has been dug [illegible] great [illegible] small narrow [illegible] which converge toward the south and enter the Mancos. The plan of the surface of the mesa would give the appearance of a number of fingers stretching up from the south and spreading out toward the northern end. In other words, the fingers of the mesa are, as though drawn from north to south, dug out the long narrow valleys, leaving only thin parallel ridges rising almost to the original height. Traveling along the [illegible] of these ridges is easy, as the surface is smooth. Numerous cattle trails wind along without [illegible] the trees, and on horseback the ground can be covered as rapidly as the rider can dodge the stiff pointed dead, lower branches of the trees; but in attempting to go from one side to the other it is almost impossible to make progress. Coming to the edge of a precipice, the explorer wanders up or down until he [illegible] finds a place where the rock has been broken down, and on reaching the bottom of the valley he must again search, perhaps for hours, for an opportunity to climb out.

About the only sure and practicable way of visiting various parts of the mesa is to ascend near its upper edge, at Point Lookout, and then keep along the narrow rim in this way, passing about the heads of the different finger-like gorges. There is here a trail traveled by pack animals. At places the

ridge is so narrow that the rock goes down almost vertically on one side into the Montezuma valley and on the other into the head of the small canyons that lead to Mancos river. A misstep would throw a person [illegible] down either slope.

The peculiar form of the mesa is due largely to the existence of a heavy layer of sandstone which forms the top, capping and protecting the softer underlying rock. This weathers and breaks in almost vertical cliffs all around the outer edges. In the interior of the mesa, however, at the head of the numerous small canyons, erosion has proceeded in a peculiar manner and one which was found by the aborigines to be highly favorable to their purposes. Along the edges near the top of the canyon certain portions of the sandstone have weathered, leaving great shelves, protected above by the overhanging masses. These shelves can be reached often with great difficulty, as the cliffs above them may be 100 feet or more vertically, and access from below is almost impossible. The roof of these openings gradually slopes down to the floor, so that these great horizontal [illegible] 50 or 100 feet, and in length may stretch for several hundred feet.

Around and on the mesa are found numerous fragments of pottery and flakes of stone, and here and there mounds of refuse, showing the location of ruined houses or towns. The numerous [illegible] ruins of stone towers on prominent points show that the arts of defense were an important feature of their life. It is, however, under the shelter of the great overhanging rocks that we find the ruins in most perfect condition. Here, in the dry climate, protected from the occasional fierce storms, the dust of centuries has accumulated and even organic matter has barely undergone any change. The great stone houses and towers rise story above story, and behind, in the piles of refuse thrown into the rear part of the cave where the roof approaches the floor, are the worn out sandals [illegible] the clothing of these, such as the [illegible] of relics, has retained its texture and even its [illegible]. No fragment of metal has been found, but all the implements are of bone, wood, or stone.

The buildings are constructed of carefully squared rock, each of which must have been brought some considerable distance by steep ladders or along the narrow trails which lead to the town. Water was had in some cases by small springs or seeps within the rock; in others it was brought in earthen jars, carried, presumably, on the heads of the women, from the springs far down in the valley. The foot and hand holes cut in the rock still show the paths by which the dwellings were reached, and in places these terminate on overhanging cliffs, where it is obvious that ladders must have been employed.

These ruins have been an object of superstitious dread by the Utes or Indian Indians living in the neighborhood and have not been disturbed by them through centuries; but with the advent of the white man destruction has come, and many of the finest have been wantonly pulled to pieces or injured in the search for relics. In particular, an estufa or council-chamber, situated below the surface of the ground and otherwise remaining in perfect condition, was partially pulled to pieces in order to take some of the logs of the roof to exhibit at the World's Fair at Chicago. Various individuals have made a business of collecting the pottery from these ruins, rifling the graves and selling the mummies and the skeletons to tourists or to collectors of curiosities. Several museums have sent exploring parties into the vicinity, which have obtained material for exhibition. Although these ruins are presumably the property of the National Government, little, if anything, has been done to preserve them, and the National Museum possesses comparatively few objects from this locality. It is a matter of regret that these interesting ruins are not being preserved, as, even from a commercial aspect, they would have an ever-increasing value to that part of the State in attracting tourists from all over the world. The place of the [illegible] [illegible] is estimated that at present 75 persons a year [illegible] made to profit by these old [illegible]. The trip is made from Mancos, a town on the Rio Grande Southern Railway, one day is required to reach the ruins on horseback, another day or more in visiting the ruins, and the greater part of one day in returning to the railroad. It might be practicable to construct a wagon road, and some steps of this kind should be taken to facilitate travel, and adequate protection provided to prevent the tearing down and injury of the buildings by careless visitors.

THE GEOSPHERES*

By W J McGee

Vice-President of the National Geographic Society

Perhaps it is my first duty, as it is my privilege, to offer you a word of welcome on behalf of the Society which I [illegible] the [illegible] represented [illegible] of the National Geographic [illegible] own way [illegible] educational work. Speaking for the Society, Mr President and [illegible] ladies and gentlemen of the National Educational Association, I [illegible] welcome to Washington, and place at your disposal [illegible] facilities which [illegible]

Before carrying you away from the earth's surface, which has [illegible] I wish to confess that I labor under a certain embarrassment. In the first place, I am [illegible] to speak on another [illegible] subject. The subject was chosen by Major J W Powell, first [illegible] of you, [illegible] first explorer of the Grand Canyon, the noblest piece of exploratory work in the history of our country [illegible] geologist and [illegible] U S Geological Survey of the [illegible] and founder of the Bureau of American [illegible] one of the [illegible] America has produced. [illegible] natural [illegible] his own way.

Again [illegible] belong to the class of knowledge [illegible] those who [illegible] knowledge, placing [illegible] of moving [illegible] from place to place [illegible]. I apprehend that my ideas may seem vague and my expression [illegible] appeal to your [illegible] useful to the [illegible] of American youth for whom you stand sponsors.

First as to definitions: which terms rendered the more necessary for the reason that the essential ideas which I wish to express have not yet found their way into the dictionaries. As true early in the history of knowledge men have recognized the atmosphere—i. e., the body of air above the earth. At first the [illegible], it became more and more [illegible] [illegible] [illegible] and now accepted [illegible] [illegible] and [illegible] know the atmos[illegible], here as a gaseous envelope surrounding the solid earth, an envelope composed of a complex mixture of substances, chiefly of oxygen and nitrogen. This atmosphere is one of the geospheres, the outermost of four.

Since the beginning of knowledge, too, men have perceived the waters of the earth, and, as time has gone on, they have recognized more and more clearly the substantial unity of the standing waters of ocean and bay and lake, the running waters of springs and rivers, and the solid waters of Arctic and Antarctic snows and the glaciers of mountain and plain, and they are coming to extend that unity to include the aqueous vapor of the air, one of the constituent gases of the atmosphere. Water is a definite mineral substance existing in three forms, as solid, liquid and gas, though chiefly in the second form; it constitutes the *hydrosphere*—the second of the four geospheres—covering the greater part of the solid earth and covered by the greater part of the atmosphere.

Human knowledge began with the recognition of the solid earth; as time passed the knowledge became accurate through the endless interactions between human mind and human environment; and today most intelligent people recognize a terrestrial sphere [illegible] [illegible] [illegible] [illegible] and rocks [illegible] [illegible] [illegible] feet, passing beneath river and lake and ocean to the antipodes, and extending from equator to pole in a spheroidal mass forming the visible solid part of our planet. Now it is only the superficial portion of this spheroidal mass which lies within reach of observation; this is the rocky crust of the earth, the subject matter of the science of geology; it consists of a wide variety of mineral substances, mainly combined in rocks of a specific gravity averaging about 2.7 [illegible]. The earth-crust forms the lands of the earth and the beds of the oceans; most of the geographic and topographic features so well known to the [illegible] [illegible] are built up or carved out of it: the continents, the islands, the valleys, the mountains of the world represent the vast [illegible] of [illegible]

[illegible] which [illegible] convenient to call the *lithosphere*—[illegible] of [illegible] geospheres.

Whose observation of terrestrial things ends with the atmos-[illegible]

necessary [illegible] of the [illegible] of the [illegible] that [illegible] of the planetary mass [illegible] depths [illegible] the reach of [illegible] vision. New knowledge of the earth's interior [illegible] not through geology but through the sister science astronomy. You are aware that within recent years astronomers have re-[illegible] to system our sun, the planets and moons [illegible] satellites which follow the planets, and the long-[illegible] rings of Saturn—the various members of our solar system; and the paths of the planets and satellites have been surveyed, while each of the bodies has been measured [illegible] that their [illegible] and densities are known [illegible] accuracy. Let me illustrate the accuracy of [illegible] this astronomical work [illegible] by saying that each planet, [illegible] have been weighed with an accuracy [illegible] than [illegible] of the [illegible] and [illegible] paths of planets [illegible] have been surveyed [illegible] the roadways and even [illegible] ways of the earth [illegible]

accuracy [illegible] the other planets, it is true; yet [illegible] the mean density is nearly six [illegible] of [illegible] the [illegible] known [illegible] beyond [illegible] that the earth has an [illegible] exterior, [illegible] part of the [illegible] be called a *centrosphere* [illegible] the [illegible] geospheres.

In [illegible] of these [illegible] you will understand [illegible] not [illegible] to say new things [illegible] to [illegible] a new point of view [illegible] [illegible] two ways [illegible] the first [illegible] the [illegible] increased [illegible] while [illegible] I am now attempting, not to bring [illegible] to [illegible] you, but [illegible] old [illegible] in a new way, and thus [illegible] a [illegible] of observations [illegible] the [illegible] of [illegible]

Let us now consider the relations between the geospheres.

In the first place, the matter of the geospheres is unlike in state or physical condition. The atmosphere is almost wholly gaseous; the hydrosphere is for the most part liquid, though in part solid and in small part gaseous; the lithosphere is almost wholly solid, though a considerable part is [illegible] nearly so, [illegible] the air, while a small part may be liquid under temporary and local circumstances; for the present the centrosphere may be considered a transsolid. Thus the four geospheres represent the three well-known states of matter together with a fourth state which is not certainly known from direct observation. It is the universal interrelation between the three exterior geospheres that gives character to the earth as the theater of life and the source of humanity; for plant and beast and man are alike dependent on the lithosphere for the solid part of their bodily substance, on the hydrosphere for the [illegible] of their sustenance, and on the atmosphere for the breath of life.

In the second place, the exterior geospheres at least are, despite their differences in physical condition, to some degree interlaced. The greater part of the atmosphere floats over the waters and lands of the earth as a [illegible] mantle growing [illegible] extending outward; an early estimate of its thickness was forty-five miles, but the American physicist Woodward has recently shown that the outer portion is much less dense than at first supposed, and that the entire thickness of the mantle extends [illegible] radius of the solid earth. A small part of the atmosphere is [illegible] in the waters of the hydrosphere, especially the running waters of rivers and brooks, much air [illegible] passes down into the lithosphere, filling interstices in the rocks and playing an important role in the chemical and physical changes ever proceeding in the earth crust. In like manner, [illegible] the greater part of the hydrosphere exists in the [illegible] rivers, snow fields and glaciers, a considerable volume [illegible] into the atmosphere in the form of aqueous vapor, and a much greater volume permeates the lithosphere as ground water or in still more intimate [illegible] with the [illegible] earth-substance [illegible] material of the lithosphere is in some part dissolved or suspended in the waters or afloat in the air. At the same time there is an obscure interrelation between the lithosphere proper and the centrosphere, manifested in volcanic and other phenomena and perhaps in the presence of [illegible]

the rocks, for there are certain reasons which cannot now be set forth for regarding the centrosphere as an aggregation of consolidated substances, much as the lithosphere is an aggregation of lithified substances. The blending of the external geospheres is especially intimate where the three are in contact, i. e., about the terrestrial surface on which men live and with which geographers deal; and the soils, the plants which subsist on the soils, the animals which subsist on the plants, and the crowning human organism which dominates all the others are products of the commingling.

Just as the geospheres are intermingled in substance, so they are in some measure intermingled in internal movements. The atmosphere is an aerial ocean, ever astir with currents due primarily to the rotation and revolution of the sphere and to movements depending on the density and volume of the atmosphere and lithosphere; the waters of the ocean are evaporated into the atmosphere, carried far in its currents as aqueous vapor, and then precipitated to flow back again as fresh water, while the body of the ocean is ever moved by currents set in motion by the ever moving atmosphere as well as by those produced by rotation and revolution; the lithosphere is constantly destroyed and reconstructed by the moving waters of the hydrosphere, while the earth-crust is warped and continents are lifted and sea bottoms depressed by the [illegible] movements of the centrosphere. So the internal movements of the geospheres are interrelated, and most of them, from the [illegible] of the earth-crust through which continents are lifted and [illegible] to the trade-winds and oceanic currents, may be traced to the motions of the centrosphere.

Let us now consider for a moment how the conditions and relations of the external geospheres would be affected by circumstances which at first glance might seem trivial, for thereby we may see more clearly how delicate are the adjustments on which terrestrial life and human activity depend. Suppose the temperature of the earth were raised, say, 300° F: what would follow? Our common sense, born of experience, tells us that much or all of the hydrosphere would cease to exist as such and become a part of the atmosphere, that the atmosphere would thereby be multiplied in volume and density, changed in substance, and modified in movements, yet that the lithosphere would remain substantially unchanged save that some of its substances would be dissolved in the denser atmos-

yet even so slight a change in circumstance as an increase of temperature by only 200° would remove the hydrosphere from the earth and greatly densify the atmosphere.

Let us next consider the effect which would follow the reduction of the temperature of the earth by, say, 400° F., something we should have been unable to do a generation ago, but which we can now do easily by reason of recent experiments and discoveries in physics. You will remember that about a score of years ago Cailletet of France and Pictet of Switzerland began to liquefy different gases by the application of pressure at low temperatures; many of you know that this line of experimentation was continued by the distinguished chemist and physicist of London, Dewar, who liquefied one gas after another until every gaseous substance known to man, including hydrogen, has been reduced to the [illegible] state; and I am sure that you know that an American, Tripler, has recently supplemented the work of the European scientists and has learned to liquefy air in large quantities at low cost, by the [illegible] application of pressure and artificially reduced temperature. [illegible] in every way, is worthy of more than passing note, for his advance has given man's mind a new hold on the powers of nature which promises practical applications vieing [illegible] with the great advances promised by electrical control when [illegible] first began to utilize electricity for mechanical and other purposes, [illegible] Now, liquid air is a little [illegible] than water and has a boiling point of 312° below zero, F. So we know that if the temperature of our planet were to be reduced by 400° the atmosphere would [illegible] and would shrink to [illegible] the hydrosphere of the present [illegible] and its materials [illegible]; we know, too, that long before the reduction was complete the hydrosphere would [illegible] and would become a part of the lithosphere, for the waters of ocean and lake would be congealed; as we know from Tripler's experiments [illegible] masses of crystals, [illegible] under lower pressure, just as granite and limestone and other rocks are at the present temperature; [illegible] one rock added to the rock which now exists, by this transformation the [illegible] of the atmosphere would be [illegible] by that of the present oceans, the pressure at sea level would [illegible] of liquid air only a dozen or a score of yards [illegible] would

wash the frozen globe, leaving continents and islands rising above its surface in a geographic configuration differing not greatly from that of the present. Over this globe no air would float save possibly a light [illegible] vapor, or low tension [illegible] our atmosphere; and no man or [illegible] the traces of a [illegible].

Consideration of the profound modification in the exterior geospheres necessarily following changes in temperature which can only be considered as slight in comparison with the wide temperature range even of our solar system aids us in understanding the nature of the conditions which attended the early stages in the development of our planet. The earth as a whole is apparently a cooling body, though the rate of cooling must [illegible] infinitesimally slow. [illegible] must have been warmer, a greater part of the water must have been held out as vapor in the atmosphere, which must have been heavy with vapors and the fumes of solids [illegible] the changes necessarily produced in the geospheres by diminished temperature enable us to take a long look into the future and foresee the fate which awaits our planet, unless, indeed, the fate may be averted by [illegible] of human ingenuity. There are many indications that the mechanism of the solar system, and, indeed, of the stellar system, is running down. We know that the water of the earth is going into new combinations from year to year as a constituent of the rocks of the lithosphere; we know that the water area of the globe is diminishing from age to age as the continents [illegible], for the latest deposits with which geologists are concerned were laid down in water [illegible] are largely if not entirely accumulated on land; there are less [illegible] to-day, while the record of geology indicates that during the Carboniferous and earlier ages [illegible] of the earth were [illegible]. And, just as the hydrosphere is going into the lithosphere by chemic absorption as well as by [illegible], so are the atmospheric oxygen and nitrogen of the atmosphere slowly separating and combining with the substances of the lithosphere, [illegible] the hydrosphere. [illegible] planetary history, [illegible] suggest a time when the now deep-laid [illegible] centrosphere was enveloped only by heavy atmosphere, with [illegible] save possibly [illegible], and [illegible] save possibly [illegible] of its own [illegible]

liquefied by relief from pressure like the lavas of later time and the [illegible] of slowly segregating waters and accumulating rocks formed through interaction between the gaseous atmosphere and the cooling centrosphere, [illegible] indicate the [illegible] ture and other conditions. The changes [illegible] gave a trend of climate to absorption of air and water into the rocks, leaving a dead product of centrosphere and lithosphere only, swinging lifeless through space like the frozen moon; yet there is a fourth [illegible] in a fifth geosphere produced through delicate interaction among the three exterior spheres of the earth, lying about the common boundary of the three, dependent on all, yet able (at least in some measure) to control them [illegible] *psychosphere*, [illegible] but potent and ever-growing [illegible] which bids fair to envelope the world.

Just a few words more, if you please, concerning the general relations among the geospheres. The atmosphere is a body of gas conditioned primarily by temperature; the hydrosphere is a [illegible] lithosphere is a mass of rock conditioned by temperature, gravity, and a more complex chemic affinity than is found in the mixture of air or the compound water; the centrosphere is a mass of a probably metalloid body, conditioned in ways that are not well known; the several geospheres combine to form a planet conditioned by temperature, gravity, chemic affinity and perhaps other agencies, which extend to other planets and satellites and suns of the cosmos. So the features of the geospheres, i. e., the characteristics of our planet, are largely determined from without; yet it is not to be forgotten that each geosphere contributes to the making of the others, and thus to the making of the planet, and in some measure to the shaping of the cosmos [illegible] has already been indicated [illegible]

Let us now proceed to consider a few of the general relations among the geospheres which affect cosmic economy. We have good reason for supposing that the earth is a cooling body, that some of its primeval heat is constantly passing into space to affect the weary radiation of other bodies; but do we know why the temperature of the earth is not lowered more rapidly—why the lowering is so slow as not to be detectable by the observations of history? We know that if the earth were simply [illegible] through interstellar space and cooling by the

and [illegible] of its heat into space it would soon be refrigerated; [illegible] we know too that in this case the temperature of its surface would be determined mainly by two factors, viz: (1) the energy or store of the ball itself, and (2) the temperature of exterior space. Now on examining our planet as a ball and the [illegible] as a segment of the [illegible], we do not find that the temperature of its surface is determined or even perceptibly affected, by its own proper heat; we do find that the temperature of the external earth is determined by the heat received from the sun. It follows, of course, that the earth is not merely a cooling ball exposed to cold space. On examining more critically the conditions determining our temperature we find them to be two, viz: (1) insolation or reception of solar heat, and (2) conservation of a considerable part of the heat for a time by a terrestrial mechanism. This mechanism resides chiefly in interaction among the exterior geospheres. The most important conservative agency is the aqueous vapor of the air, which not only stores quantities of heat to be given off on condensation, but serves to check radiation from the earth into space. When the sun shines on the ocean, a film of water is evaporated to be borne high in the air and carried far over the continents, where it [illegible] and a part of its heat is employed in raising the temperature of surrounding air, water, and rock; so that water not only in the form of vapor stores heat more effectively than any other substance [illegible] with which we are acquainted, but [illegible] aqueous vapor acts as a blanket checking evaporation; dry air is diathermous, but vapor-laden air checks radiation from the earth as it checks radiation from any body. Since there is no part of the earth, even on the deserts and polar barrens, in which there is not an appreciable quantity of aqueous vapor in the air, this substance forms a clothing for the earth, ameliorating its temperature, rendering it habitable, and making it what it is below the stage of [illegible].

There is another class of special relations between the geospheres which I should like to bring before you, partly as a new discovery. As before pointed out, the rocks of the earth crust of [illegible] are permeated by water in the form known technically as ground water or [illegible].

A distinguished geologist, Professor Van Hise of the University of Wisconsin, has recently shown that this ground water plays an important role in changing the texture and structure of rocks, especially at depths where the pressure is great and the

temperature higher than at the surface. It is a well known [illegible]

rates them into their simple components or ions. Accordingly [illegible]

perature, as is frequently the case deep in the earth-crust, the rock-matter is dissolved at the points and planes of greatest pressure and precipitates or redeposited at neighboring points and planes of less pressure, so that, for example, a crystalline mass of wet and [illegible] rock-matter may be permanently distorted by [illegible] and pressure on opposite faces, the crystals gradually yielding to the stress in the direction of pressure and elongating themselves in the orthogonal directions. Thus [illegible] is properly [illegible] agent that [illegible] of the hydrosphere which penetrates and suffuses the lithosphere and determines the texture and structure of most of its rocks. It has transformed the muds and sands and [illegible] slimes of original [illegible] into shales, sandstones, and limestones; in some [illegible] it has reconverted or metamorphosed these rocks into [illegible], quartzites, and marbles, and [illegible] it has [illegible] remolded [illegible] deposited [illegible] into [illegible] and other crystallines. This extreme effect of water is peculiarly instructive in that it reveals something of the character of the [illegible] whose [illegible] materials are [illegible] of observation [illegible] water as a solvent [illegible] in the [illegible] of lavas, veinstones, and other rocks of [illegible] origin. There is reason for regarding the atmosphere as a [illegible] and the hydrosphere as a [illegible] serving [illegible] interacting with [illegible] to develop the [illegible] and [illegible] ultimately [illegible] not be [illegible] for the present. Yet it is well [illegible] between [illegible] which [illegible] by the waters [illegible] of the surface [illegible] the [illegible]. The two [illegible], there are [illegible] shown by the [illegible] escape of the [illegible] from the formation of the [illegible] and from the [illegible] in the form of extruded lavas and [illegible] shown also by the [illegible]

and to some extent, in the uplifting of mountains; it is still easier to trace the still more interesting though obscure function of the apparent reduction of loose-textured solids to a denser texture in provinces subject to long-continued loading by deposition of excessive volumes of sediment—e.g., the Gulf of Mexico, the world's most notable province of loading, whose configuration suggests a hypogeal "sink"—which may be simulated experimentally by pouring a few drops of [illegible] and [illegible] into a vessel liquid at the critical (or [illegible]) point; but this most interesting relation may also be passed over for the present with the single suggestion—made by the [illegible]—that the solid [illegible]osphere and transient [illegible]sphere appear to be interconvertible at a critical point of tem-

[illegible]

may be considered interconverted in state and in substance on passing a critical point conditioned by the same factors, and

[illegible]

most puzzling facts in geology.

There are other interrelations between the geospheres, interesting almost beyond measure; time will not permit me to mention a tithe or even a hundredth part of them; yet there is one more relation which appeals strongly to those geographers who, like myself, always see the lands and the waters from the human standpoint, and I beg your indulgence for the three minutes required to set it forth briefly. My predecessor, Mr Redway, has admirably defined for you the natural provinces of America and shown you that the features of the land, formed during the ages by the work of running waters, shape the character of our people. I trust he will permit me to add a word to his theme as well as to that of the thinker for whom I am speaking. In what we call the Western hemisphere the land and the waters are so [illegible] as to form a single continent, the North American continent, lying chiefly in the North Temperate zone; during the ages the centrosphere has heaved and sunk according to its wont and has interacted with the atmosphere and hydrosphere in such manner as to produce an abundance of far-reaching [illegible] [illegible] mountains, stretching down to broad plains, mantled everywhere at the surface with fertile soils, charged often at the depths with mineral treasures—the wealth much [illegible] wasted on unintelligent aborigines until men of thought and action came to claim it. Then, since the lands —

were found and fertile, agriculture spread more rapidly than ever before, more rapidly than would be possible under other conditions; next the magnificent distances and rich produce called for improved transportation facilities, and steam was harnessed more effectively than would be possible under other conditions. Mechanical invention was [illegible] by a broad-[illegible] and widened the views of men [illegible] inspired by [illegible] Freedom, and America became a nation of inventors, a people of applied science; geography was studied more broadly than would be possible in a petty province, [illegible] grew into a science of measures, inspired by the breadth of the formations and their wealth of resources, [illegible] by intelligence broad as the land and today the geologists of the country lead the world in their science. The sister sciences were invigorated by the association; I have said that the solar system has been weighed and measured with unparalleled accuracy during recent years, and may now add that the work was done by American genius, and that today the shipping of the civilized world is guided by [illegible] based on the American work. And [illegible] of America by reason of [illegible] [illegible]. We have had better opportunities than those of other countries for research concerning mankind; we have in Washington and other cities [illegible] [illegible] country on the face of the [illegible] every [illegible] then we have a wider range of culture constantly before us than any other that [illegible] from savage through bar-barous tribes up to the representatives of the [illegible] [illegible] [illegible] and finally to our own enlightened people standing on the highest plane which mankind has ever attained, the plane on which social organization is based on [illegible] from [illegible]. We have every stage [illegible] before us, and [illegible] we have been able to carry on [illegible] [illegible] of anthropology than the world has seen [illegible]. Especially [illegible] country has [illegible] forward in the race for intellectual attainment, surpass-ing all other nations, [illegible] [illegible] kept pace with our development of knowledge. The [illegible] of English [illegible] in Egypt [illegible] [illegible] to America, knowing that, despite the [illegible], the order can be filled more quickly than at home, [illegible] more [illegible] than the

engineers of other countries combined. American engineers are called to the [illegible]. Our progress in [illegible] has [illegible] with our progress in knowledge to strengthen [illegible] character, to produce a [illegible] forceful individuality greater than other countries know—and [illegible] splendidly expressed in the [illegible] before me. This exalted individuality is displayed in [illegible] perfect [illegible] of thought, in more complete [illegible] of [illegible] than the world has ever seen before. It has revealed [illegible] moral [illegible] and strength of character [illegible] [illegible] workmanship—the [illegible] expression [illegible] America's latest revelation to the world. The [illegible] of America gives national character to America, [illegible] the spontaneous products of free minds [illegible] and deeper than any sentiment [illegible]

[illegible] country [illegible] the recent [illegible] which [illegible] the [illegible] of New York and the [illegible] of Arizona [illegible] stand [illegible]

the [illegible] and [illegible] expression, [illegible] army and navy [illegible] question. Complete as is our [illegible] is much more perfect in [illegible] conquest [illegible] toward [illegible] our [illegible] and [illegible] 7,000,000 [illegible] tower of [illegible] strength, are kept in [illegible] by telegraph and telephone and press, united in thought and purpose [illegible] strongest [illegible] and political [illegible] the world has seen. [illegible] the [illegible] expression of [illegible] which I have [illegible] the [illegible] hemisphere, [illegible] of the people [illegible] our [illegible] the [illegible] of the [illegible] the water [illegible] for the good of [illegible]. And [illegible] of the [illegible] resources of the [illegible] spheres, [illegible] freedom and [illegible] liberal [illegible] like that which you [illegible] that has placed America in the foremost rank among the nations of the earth.

At a special meeting of the National Geographic Society, held in the Lecture Hall of the Boston Society of Natural History, Boston, Massachusetts, August 25, 1898, Vice-President W J McGee in the chair, the following resolutions were adopted:

Whereas, Through the increasing consumption of forest products, the destruction of forests, and the vast extension of means of transportation, questions [illegible] bearing [illegible] rapidly [illegible] grave international [illegible]; and

Whereas the National Forest Association of Germany has undertaken to collect [illegible] the world [illegible] forest information and statistics of [illegible]; therefore

Resolved, That the National Geographic Society express its deep sense of the [illegible] of the work thus begun, and pledge its [illegible] in the investigation; and

Resolved, That a committee of three be appointed by the chair to communicate these resolutions to the National Forest Association of Germany and to take such other steps as may be necessary to carry them into effect.

In conformity with these resolutions, the chair appointed Mr [illegible] Brewer, of New Haven, and Arnold Hague, of Washington, as a committee to take appropriate action on behalf of the National Geographic Society.

MISCELLANEA

It has recently been ascertained that the British consumption of sugar [illegible] per head per annum [illegible] that of France, Germany, Austria, Holland, and [illegible].

The mineral [illegible] of Canada during the fiscal year 1897-1898 amounted [illegible], an increase over the preceding year of $[illegible]. The [illegible] aggregate value of $[illegible], an increase of $[illegible].

A Danish expedition to explore the east coast of Greenland between [illegible] and [illegible] degrees north latitude sailed from Copenhagen on August [illegible] under [illegible] Amdrup. The ship, the Godthaab, [illegible] completely equipped and is provisioned for two years.

The Duke of the Abruzzi, Prince Luigi of Savoy, has [illegible] by a successful ascent of [illegible] a [illegible] peak that had hitherto defied the efforts of the most intrepid [illegible]. The daring feat was accomplished on August [illegible].

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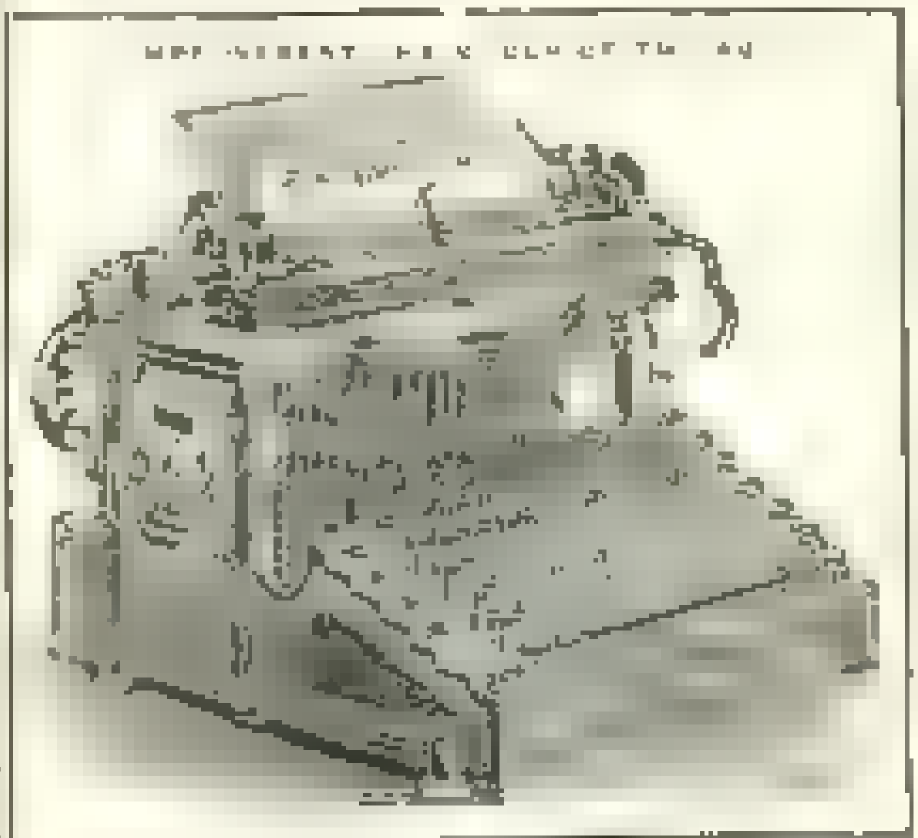

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